Rainwater Harvesting – A Sustainable Water Resource

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1.0 INTRODUCTION

Rainwater harvesting is an age old technique of capturing or trapping the rainwater on roofs or some other hard surface and storing it for reuse. The practice of rainwater harvesting had been observed in early civilisations. Since 2000BC in the Negev Desert in Israel, cisterns have been used to store rainwater run-off from the hillsides. Roman villas and cities were designed to harvest rainwater for drinking and agriculture use (Gould *et al.*, 2008).

The largest underground rainwater cistern (80,000m^3) was constructed by Caesar Justinian in 6th Century in Istanbul. Rainwater cisterns were also found in other parts of the world such as the Shanxi and Gangsu province (called shuijiao), Pakistan (called sailabas), Mexico (called chultun), Africa and the rest of the world (Gould *et al.*, 2008). Pacific Islands such as Hawaii and the Virgin Islands practiced rain harvesting. In Bermuda, there is even a public health act regulating the maintenance of rainwater harvesting installations (Salas J,. 2007).

The practice of rainwater harvesting has been out of necessity in arid and semi-arid regions. However, RWH is presently gaining recognition in the world as a sustainable source of water supply.

The resurgence of rainwater harvesting is due to the paradigm shift in developed countries towards the adoption of rainwater harvesting as an alternative sustainable source of water supply apart from traditional sources such as streams, lakes or underground water. When cities grow in size with increasing demand on water, new catchments have to be identified and dams constructed with adverse effect to the local and global environment.

Pipelines and tunnels have to be constructed over long distances involving inter-state boundary crossings. Deforestations contribute towards global warming. Construction activities and treatment plants processes consume fossil fuels, emitting carbon dioxide and greenhouse gases into the atmosphere. Moreover, not all the water to be consumed domestically needs to be of high quality involving treatment processes utilising precious energy and chemicals. The sustainable method of water supply is to capture water at source where it falls, store and utilise it there.

2.0 SUSTAINABLE ALTERNATIVE WATER RESOURCE

In a municipal or community water supply system, the supply of water is at a common standard of chemical and physical quality either for industrial, commercial or domestic consumption. It has been recognised that water for different applications may be of different quality standards. In a home, rainwater may be used for toilet flushing, laundry, carwash, general cleaning and irrigation.

A Malaysian study of the potential utilisation of rainwater shows that from a typical consumption in a household, 55% of the total daily consumption may be substituted with rainwater, i.e. toilet flushing (30%), laundry (13%), outdoor use (7%) and general cleaning (5%) (Baharuddin A., 2003).

According to the Malaysia Water Industry Guide 2007, the total water production from WTP in 2006 was 12,296 MLD and 66% (8,115 MLD) was for domestic consumption. The potential of substitution of 55% of domestic consumption with harvested rainwater amounts to 4,463 MLD, which is 36% of the total water production in 2006. The average increase in water production from WTP for the last 16 years was 470 MLD annually. So, there may be no necessity for new plants for the next nine years if the full potential of rainwater harvesting is implemented domestically.

Decentralisation of supply also reduces the vulnerability of a city or community from relying on a single life-line source during emergencies or droughts.

When rainfall is stored within the premises, there is less run-offs into the waterways, thus reducing the effects of floods during storms. The contaminants carried by the overland surface run-off are also reduced leading to less pollutants being transported by the waterways during rainfall.

This recognition has led the paradigm shift in the utilisation of harvested rainwater for a sustainable water supply for the industry as well as household consumption.

3.0 DOMESTIC RWH SYSTEM

The components of a domestic rainwater harvesting system consist of the collection system, conveyance, storage and draw-off.

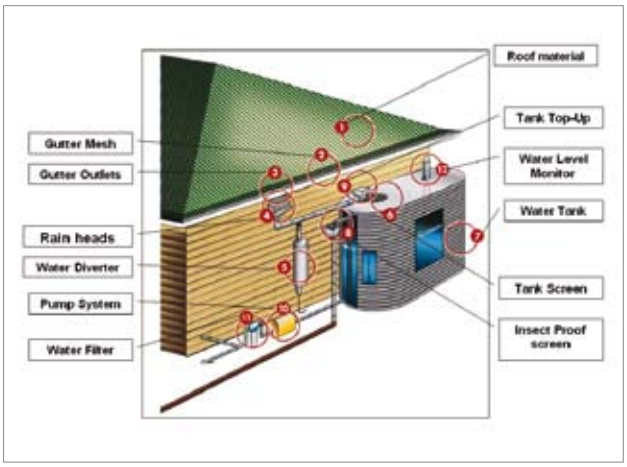

Figure 1: A Domestic RWH System (Source: www.rainharvesting.com.au)

Table 1: RWH Potential in Malaysia

Domestic Rainwater Harvesting Potential (Malaysia)

Month	Rainfall (mm)
Jan	107
Feb	200
Mar	266
Apr	293
May	217
Jun	153
Jul	150
Aug	195
Sep	237
Oct	248
Nov	235
Dec	219
Total	2,520

Availability
Total annual rainfall = 2500mm
Average D/S Link House Roof Area or harvesting Rainwater = 100sqm
Allow capturing efficiency of 75%
Vol of Rain Water = 2500 x 100 x 75%
= 188 cu m per year

Demand
From consumption estimates potential use of RW in a household is
15cu.m x 12 months = 180 cu m per year

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3.1 Catchment Surface

The catchment surface or roof shall be smooth and not contain toxic substances. Some suitable materials are clay tiles, concrete surfaces, galvanised iron, aluminium, fibreglass and colour bond metal sheets. Lead based paints shall not be used; even as primers. Unsuitable materials are asbestos, lead based paint coating, bituminous coating, thatched roof and timber tiles which harbour microorganisms and has a tendency to impart taste to the water.

3.2 Screens and Large Debris Diverters

The rainwater runs along the roofing surface into a gutter and downpipe system and into the storage vessel. The large debris, dead leaves and coarse materials that is collected by the flowing rainwater is trapped in coarse screens or gutter guards of 4mm openings made from stainless steel, galvanised steel or plastics. These self-cleansing screens may be (i) ingeniously fitted to cover the gutter drains, (ii) placed below on the underside of the gutter drains outlets to down pipe inlets, (iii) along the downpipe before the inlet of the storage vessels. These screens are also termed as "leaf-eaters" or "leaf-beaters".

A patented German product called a vortex filter is a self-cleansing device that diverts the debris and coarse grained contaminants from the rainwater whilst capturing more than 90% of the rainwater for storage.

3.3 Filters and First Flush Water Diverters

The rainwater may be filtered through a graded sand filter bed or other media which has to be regularly maintained. However, a "first flush diverter" device may be used which diverts the first predetermined amount of rainwater from the roof, away from the storage vessel. This first part of the rainwater carries deposits such as droppings, dead insects, particulates, dirt, which accumulates on the roof surface during prolong dry spells. In Australia, a rule of thumb is to allow 2mm of rainfall to be diverted. The Texas Manual on Rainwater Harvesting, published by the Texas Water Development Board, 2005, recommends a minimum of 10gals (38 litres) for every 1,000 sqft (95sq.m.). In a Japanese study on Tokyo in 1986, only 1.5mm of rainfall is affected by the pollutants that have accumulated on the capture surface.

3.4 Storage Vessels/Tanks

Rainwater are stored in tanks above ground, partially below ground or completely buried. These vessels of various shapes and sizes can be constructed or purchased commercially. The tank materials are concrete, ferrocement, fibreglass, steel and plastic. The size of the storage tank is dependent on the required consumption, roof area, rainfall volume and supply security. In a South Australian study on typical domestic application of 10-20cu. m. of storage, about 65% of the rainfall can be captured with 90% security. The storage may be connected for back up topping from mains supply where available.

The tank has to be opaque and vermin proof with proper ventilation to avoid anaerobic conditions. The absence of light inhibits the growth of algae, which is food for microorganism, protozoa, bacteria and viruses, which may reside in the storage vessel.

3.5 Delivery System

The draw-off point from the storage tank should be located at a sufficient level above the tank bottom so that the accumulated sludge, if any, is not drawn down. It is also important to locate and attach a device at the inlet to the storage tank to maintain quiescent conditions in

Figure 2: (a) Leaf Beater

(b) Gutter Screen

(Source: www.rainharvesting.com.au)

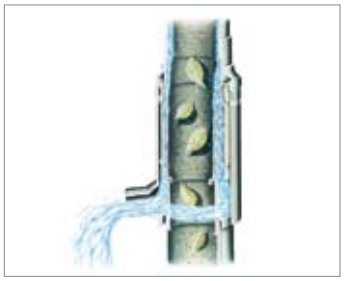
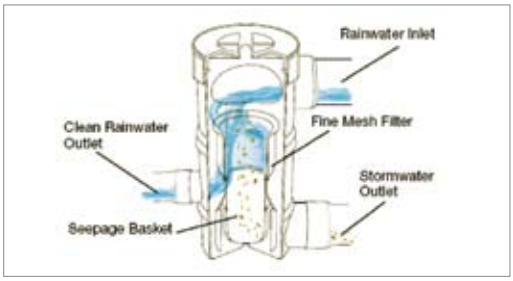


Figure 3: (a) Screen in downpipe



(b) Vortex filter

(Source: www.wisy.de)

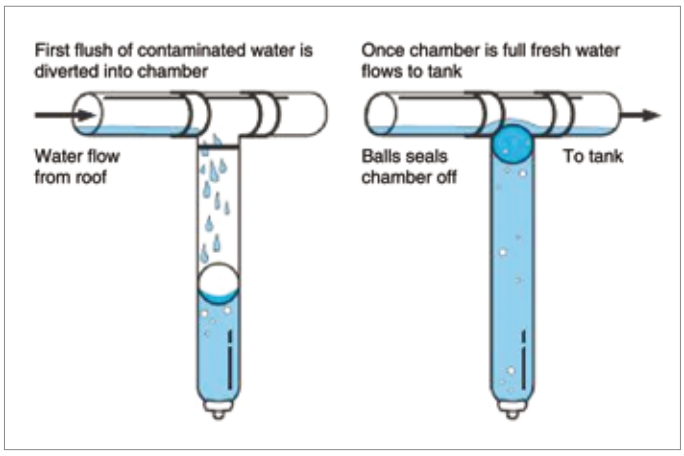


Figure 4: First Flush Diverters

the tank when new rain water is filling the tank.

4.0 RAINWATER HARVESTING PRACTICES

Australia has been promoting RWH harvesting very strongly with well drafted regulations, guidelines and even a registration of Green Plumbers licensed to undertake the installations of RWH systems. Local councils and water authorities are giving rebates for the installation of RWH systems used for toilets, laundry and hot water, *e.g.*; South Australia Water gives a rebate of up to $1,000 for retrofitting a RWH system in a home. From July 2006, a RWH tank is a requirement for the building approval process in South Australia, NSW and many other local councils. The Australian Bureau of Statistics in a 2007 survey reported that 19% of Australian households use rainwater tanks for their source of water with South Australia having 45% of households with rainwater tanks and up to 69% of households outside of Adelaide.

The Texas Water Development Board was a pioneer in producing a well documented manual entitled "The Texas Guide on Rainwater Harvesting", which is in demand internationally. Presently, many localities such as Hawaii, Portland City, Virginia, etc, have enacted by-laws and produced guidelines for the installation of RWH. The increasing demand on water supply and the strain on existing resources have seen the re-emergence of RWH being installed in increasing numbers in the United States. In recognising that RWH practice contributes to the conservation of water and the environment, rebates are also paid out *e.g.*; in Texas, $450 is paid for each installation.

A Dutch organisation called RAIN (Rainwater Harvesting Implementation Network) has been constructing rainwater harvesting systems in Ethiopia, Nepal and West Africa. From 2004 to 2007, a total of 414 installations have been completed with a total capacity of 20,000m^3 of drinking water. There is another 800 installations to be carried out under their program.

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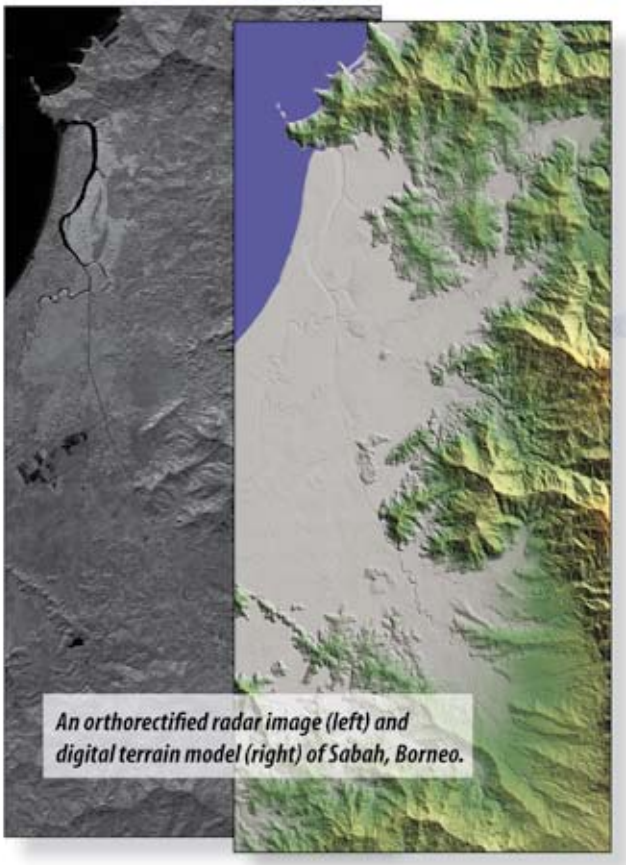

An orthorectified radar image (left) and digital terrain model (right) of Sabah, Borneo.

Many German cities charge home owners an annual rainwater drainage fee, which is waived if the rainwater runoff is retained or returned to the ground whilst grants and subsidies are available to encourage home owners to construct rainwater tanks. Between 1993 and 1997, the government in Hessen funded a total of 114 rainwater utilisation systems for use in some "sensitive areas for hygiene", such as kindergartens, schools, homes for the aged, etc.

Rainwater Harvesting at Frankfurt Airport in 1993 saves approximately 100,000m3 of water per year. The system collects water from the roof of the new terminal which has an area of 26,800m^2 and conveys it to six tanks in the basement of the airport with a storage capacity of 100m^3. The water is mainly used for toilet flushing, watering plants and cleaning the air conditioning system.

At Technical University of Darmstadt, a colossal rainwater harvesting system installed in 1993 combines harvested rainwater and used water for toilet flushing and supplies it to the laboratories of the university for cooling and cleaning purposes. Ever since this system has been installed, only 20% of the water demand is covered by drinking water, amounting to a saving of 80,000cum of drinking water per year (http;//rainwaterharvesting.org).

In Singapore's Changi Airport, a RWH system collects rainwater falling from the runways and surrounding green areas and then treats the water, which is used for toilet flushing and fire drills. The rainwater accounts for 28% to 33% of its total water used.

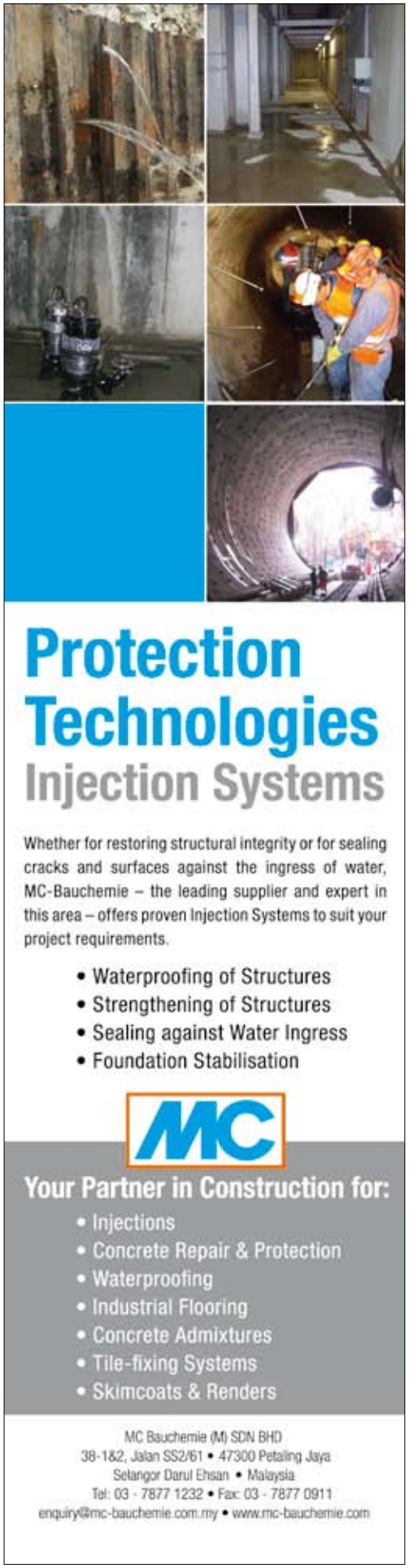
In Bangladesh, rainwater collection provides safe drinking water in arsenic affected areas. Since 1997, about 1000 rainwater harvesting systems have been installed in the country by the NGO Forum for Drinking Water Supply and Sanitation. Its primary objective is to improve access to safe, sustainable and affordable water in Bangladesh. The rainwater that is harvested is used for drinking and cooking, and is accepted as a safe, easy-to-use source of water. Water quality testing has shown that the water can be preserved for four to five months without bacterial contamination.

In Sri Lanka, an amendment to the UDA Building and Building Regulations 1986 was gazetted in July 2007 which requires every building to have provision for Rainwater Harvesting for obtaining a Development Permit for construction (LRWHF 2009).

In Malaysia, a successful commercial RWH installation at a shopping complex in Petaling Jaya captures rainwater from the roof car park. The water is stored in a basement underground tank (3,248m^3) to be pumped and used for toilets flushing and landscaping. There was a reported savings of 30% of its water

RW Storage Tank

Household Tank



bills. There are many other places in the world where rainwater harvesting has been successfully used as a means of water supply.

CONCLUSION

Rainwater harvesting is strongly promoted and practiced not only in water scarcity areas, but also in urban areas of developed countries where municipal water supply is available. This situation is due to the recognition of rainwater as a sustainable source of water supply for the domestic consumer. The quality of stored rainwater has been recognised to be generally equal or even better quality than treated municipal water in some applications. When the RWH system is well maintained, the stored rainwater may even be consumed directly without treatment.

RWH practice will increase as the practice of sustainable development gain acceptance. The authorities have to acknowledge the sustainability of rainwater harvesting as an alternative water resource in the conservation of water supply with the associated advantages of integrated storm water management. Building regulations, guidelines and financial rebates have to be made available for the successful implementation of Rainwater Harvesting Systems to benefit the environment. ■

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